NASA Innovative Advanced Concepts

Printable Spacecraft: Flexible Electronic Platforms for NASA Missions Project

Completed Technology Project (2012 - 2014)

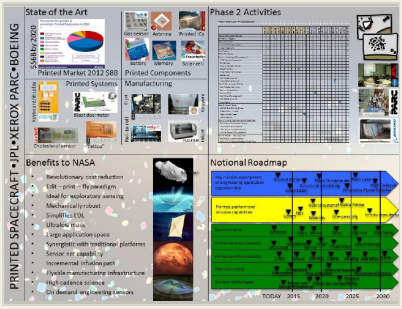
Project Introduction

Is it possible to print a spacecraft on a sheet of paper? This study fuses several existing technologies to enable printable spacecraft, including printable batteries, electronics, and sensors.

Atmospheric confetti. Inchworm crawlers. Blankets of ground penetrating radar. These are some of the unique mission concepts which are enabled by a printable spacecraft. Flexible printed electronics is a wide-ranging technology that can enhance or even enable many engineering applications. Our concept is to utilize the commercial technology of printed electronics to design and fabricate an entire end to end functional spacecraft. The novel advancement (and therefore the technical challenge) of the concept is to apply printed electronics in a multi-functional platform by implementing every subsystem that a spacecraft might need from the scientific sensor through the data downlink and have it survive and function in a space environment. These requirements push the current state of the art for functionality as well as introduce design and manufacturing compatibility challenges among the functional subsystems. Current industry growth and commercial investment is expected to advance the functionality of available basic building blocks and components synergistically with NASA's needs.

Anticipated Benefits

Atmospheric confetti, inchworm crawlers, and blankets of ground penetrating radar are some of the unique mission concepts which are enabled by a printable spacecraft.



Project Image Printable Spacecraft: Flexible Electronic Platforms for NASA Missions

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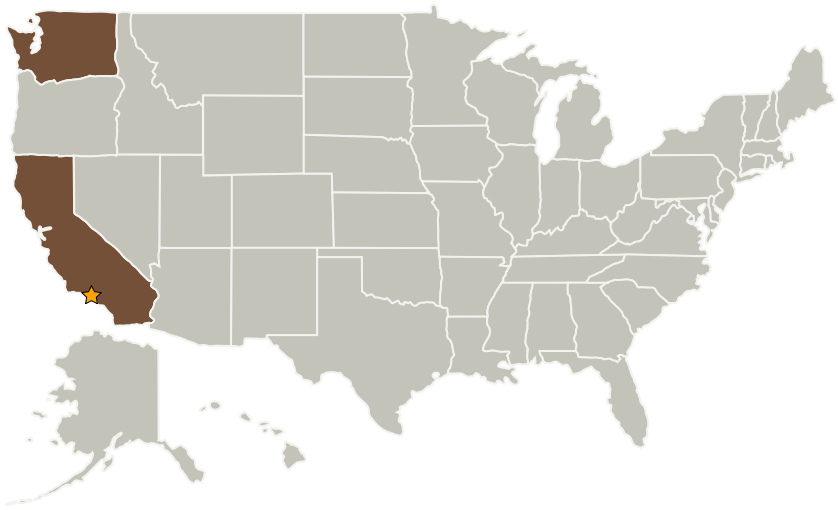
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
Palo Alto Research Center(PARC)	Supporting Organization	Industry	Palo Alto, New Mexico
The Boeing Company(Boeing)	Supporting Organization	Industry	Chicago, Illinois

Primary U.S. Work Locations	
California	Washington

Project Transitions

October 2012: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

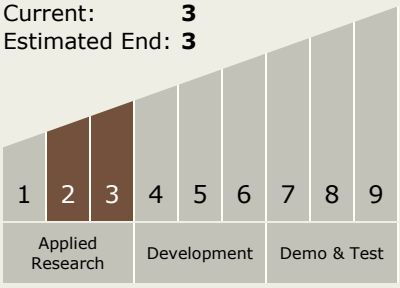
Eric A Eberly

Principal Investigator:

Kendra L Short

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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September 2014: Closed out

Closeout Summary: We believe we have addressed the NIAC program goals to study major feasibility issues of the technology with results that provide a sound basis for NASA to consider the concept for further development. By looking closely at the technical and programmatic challenges, we assessed the utilization of printed electronics in space. We specifically considered the technology in a mission context by producing a point design and a detailed analysis for the STANLE reference mission. To address the technical challenge of system integration, we designed and fabricated a hybrid printed platform that includes the functions of continuous sensor measurements, data processing and conversion and storage, and RF wireless transmission. To address the technical challenge of space environment survivability, we tested common materials and printed devices under conditions representative of space (vacuum, thermal cycling, radiation). The printed materials samples showed no substantial degradation nor did the temperature sensors. Other devices are still undergoing post-test characterization. To address programmatic feasibility, we investigated the benefits to a reference mission in terms of cost and mass. We were able to show that replacing a traditional lander with the equivalent mass of printed flutter landers saved significant cost and risk. To provide guidance on a path forward, we formulated two roadmaps -one to bring the reference mission to maturity and one to invest in progressing the technology in general. The Printable Spacecraft phase two effort accomplished everything it set out to do and more. One might be able to claim that as a result of the prototype build and environmental testing the printable spacecraft has moved forward from TRL 2 to a state between TRL 3 and 4. This task also inspired four successfully funded follow-on activities: -A Rocksat-x sounding rocket demonstration of the STANLE printable spacecraft working with a student team at Northwest Nazarene University -A NASA EPSCoR Research Initiation Grants (RIG) on printable spacecraft with Dr. Dmitri Anagnostou and Dr, Grant Crawford at South Dakota School of Mines and Technology (SDSMT) -A NASA Space Technology Research Fellow, Ian Markon from SDSMT, who will expand the materials testing and characterization program -A Flex Tech Alliance task awarded to xerox PARC on integrated sensor platforms (building on the NIAC design) for terrestrial applications.

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.2 Structures
    - TX12.2.5 Innovative, Multifunctional Concepts

Target Destination

Earth

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Images

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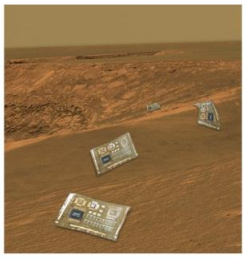
Project Image Printable Spacecraft: Flexible Electronic Platforms for NASA Missions
(https://techport.nasa.gov/image/102294)



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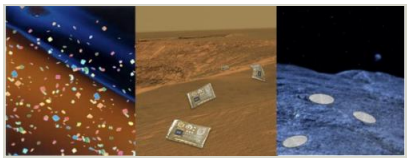

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